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# StakeCloud: Stakeholder Requirements Communication and Resource Identification in the Cloud

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***Abstract*—With the recent emergence of cloud computing, the number of cloud service providers is constantly increasing and consumers' needs are becoming more sophisticated. This situation leads to an evident need for methods which enable providers to correctly elicit requirements coming from very heterogeneous consumers. Moreover, consumers demand ways to find the cloud services which best meet their needs.**

**We propose to address the issues identified by creating the StakeCloud community platform, capable of working as a cloud resources marketplace. It will allow users to input their resource needs and provide them with matching cloud services. Additionally, in case these are not met, they can be communicated as new requirements to cloud providers. Such a contribution will improve the requirements communication and resource identification in cloud systems, bridging the gap between consumers and providers.**

***Keywords*—requirements communication; requirements engineering; cloud computing; stakeholder; cloud service**

## I. Motivation and Research Problem

Cloud computing is a new and promising paradigm [1], often described as one of the major advances in the computing history [2]. It is forecast to have significant consequences on the distribution of software and hardware commodities in the future [3], causing major changes in the way Information Technology (IT) services are invented, developed, deployed, scaled, updated, maintained and paid for [2]. The most significant advantages claimed are increased flexibility, scalability matching customers' demands, diminished costs due to hosting resources in the cloud and the pay-per-use policy, mobility and collaboration [1,4]. Therefore, cloud computing has the potential to meet both enterprises' and individual end-users' needs, as observed by Marston et al. [2] and Kim [3].

Consequently, an increasing number of cloud providers appears with a more diverse offer, while cloud service consumers' needs simultaneously become more sophisticated. This raise of supply and demand leads to new software engineering and in particular requirements engineering (RE) issues. However, as observed by Leimeister et al., many of these are often neglected [5]. On the one hand, with such a wide variety of cloud resources to choose from, consumers may not always know what best suits their needs and thus what cloud providers to select. On the other hand, providers might find it difficult to correctly elicit, understand and address the requirements coming from such diverse consumers. Moreover, there is seemingly no concrete communication link between service consumers and providers, communication among cloud stakeholders being not well supported in general [2,6].

As discussed by Liu et al. [6] and Verlaine et al. [7], RE is a critical area because ill-defined requirements can easily lead to system engineering project failures. Cloud computing brings numerous challenges in this area since the traditional methods need to be adapted and new RE methods have to be investigated. More specifically, the success of adopting the new paradigm highly depends on the degree to which requirements are correctly understood by both service providers and consumers.

Our planned contribution enables cloud service consumers to identify the cloud services which best match their needs. Additionally, it provides a method and tool-support for cloud service providers to elicit new requirements from relevant consumers, thus bridging the existing communication gap between the main cloud stakeholders.

## II. State of the Art

In general, stakeholders are defined as the people and organizations affected by the system [8,9], or who have a stake or interest in the project [10,11,12]. In the cloud computing context, the traditional relationships between stakeholders slightly change, posing new challenges [13]. The principal stakeholders are the *providers*, who supply the cloud resources, and the *consumers*, who subscribe to have access to the cloud services on-demand. In some scenarios, *enablers* (or *aggregators*) can also be present, and are usually represented by organizations which facilitate the delivery, adoption and use of cloud computing, by building the infrastructure for hybrid systems, for instance [2].

In spite of ongoing research on defining and understanding the roles of stakeholders in the cloud [2,5,14,15], this research is only in its early stages. Therefore, the results available so far are not solid enough to support more thorough topics such as communicating requirements from cloud consumers to cloud providers, and do not indicate methods for providers which could assist them in identifying consumers' needs either. As remarked by Böhmann et al. [16], there is high heterogeneity in customer requirements. As a result, one essential objective is to support service providers with

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methods and tools to address the heterogeneity issues, and to assist cloud service consumers to find resources by better communicating their needs.

Cloud computing researchers have recognized the need to address these requirements communication and identification problems in the cloud, and implemented the following approaches.

*Requirements extracted from Service Level Agreement (SLA) documents.* The method used by Lichtenstein et al. consists in retrieving requirements from SLAs [17]. This is viewed from consumers' perspective, who can consult SLAs and decide whether the specified services meet their needs or not. Although this can be seen as a step in the right direction, it is an approach which can only work for service consumers who are able to correctly define their requirements. It is a known fact in RE that users usually express needs for solutions to their problems, and not well-defined requirements or needs for particular services [18]. Therefore, this solution would only support a very small fraction of cloud service consumers. Another problem of this method is the potential lack of SLAs. There are situations when no SLA documents are provided, but rather general descriptions of cloud service performance. Undoubtedly, an SLA-based approach would not work in such a case.

*Phased process for SLAs.* One proposed idea to enable the communication between consumers and providers exploited in research is to use a phased process for specifying SLAs [19]. Despite contributing to the field, the communication aspect only enters the purchase process rather late, during the formulation of the contract, after the consumer has already chosen the preferred provider. Therefore, it does not support cloud service consumers to choose the most suitable provider according to their needs and does not necessarily support the provider to get end-user requirements soon enough either. Similar to Lichtenstein et. al's [17] approach, this also relies on the existence of SLA documents. Therefore, when the cloud service suppliers do not provide them or do not agree to get involved in such a phased process, the proposed method cannot be applied.

*Ontology mapping.* Another existing approach is to use a conceptual and formal mapping between a requirements ontology and a service ontology. This is a trial to find the correspondences between the concepts from the two fields [7] to identify how the RE aspects can be used to support specific service features. However, this is a rather general idea, which does not focus on any particular RE process or activities, and does not focus on the communication aspect.

*General critique.* It follows from these observations that the existing methods only partially support consumers' needs. Therefore, they often have to rely on search engines to look for a cloud service which can potentially meet their needs. On the providers' side, there is no method specific to cloud computing to elicit requirements from consumers. They can only utilize traditional RE methods for this (such as conduct interviews, send questionnaires), which may not always be the most appropriate due to the different nature of the cloud system. Thus, in this context, RE is seen as highly important, but under-researched area [17], which is becoming increasingly demanded as cloud platforms become more and more ubiquitous [4].

## III. IDEA AND RESEARCH QUESTIONS

Our primary research goal is to conceptualize, implement and deliver a method that addresses both cloud service consumers' and providers' needs, thus enabling better communication of requirements – the implementation will be materialized in the form of a community platform, the StakeCloud platform. On the one hand, the community platform envisioned supports consumers to express their needs and find the appropriate providers for their requirements. On the other hand, it allows providers to utilize it as a method for eliciting new consumer requirements and expanding their offering.

Starting from the research goal formulated above, our project aims at answering the following research questions (RQ):

*RQ 1: What are the functionalities and requirements for a community platform from the perspective of cloud service consumers and providers?*

It is essential for our work to first investigate the requirements for the StakeCloud platform, and to understand the real interests of both consumers and providers. We need to know what difficulties consumers currently encounter in finding solutions to their cloud-related queries, and how we can support providers to better understand consumers' needs. The future acceptance of our method strongly depends on correctly identifying these requirements.

*RQ 2.1: How can cloud service consumers be enabled to communicate their needs via the platform?*

*RQ 2.2: How can the platform be populated with cloud service offering descriptions?*

*RQ 2.3: How can consumer requirements be matched to provider offerings?*

Firstly, we need to study the potential options for consumers to input their needs into the platform. These range from using a dynamic interface to natural language processing. Secondly, the cloud services specifications need to be extracted and fetched to the platform. We will investigate the methods which support this, ranging from using existing approaches such as Web Service Level Agreement (WSLA) [20] to processing the text in the SLA documents. Having collected the information from both consumers and providers, we will study the ways in which the mapping can be done.

*RQ 3: Is the StakeCloud platform useful for cloud service consumers and providers?*

The evaluation success of our project depends on the acceptance of the StakeCloud solution by cloud consumers and providers. We expect that it will be perceived as useful if consumers can find relevant services which meet their needs, and providers can use the requirements formulated on the platform.

To answer these questions, we face the following *challenges*. To begin with, the problem we are trying to solve is rather new and the topic of RE in cloud contexts is under-researched. Therefore, existing approaches we could build our work on are scarce. Next, in spite of the fact that the communication problem is not new in the services ecosystem since it was first posed in the context of service-oriented architectures (SOA), it is addressed here at a very different level. In SOA, the service usually represented only one functionality, and the discussion focused on discovering services based on their technical descriptions. In the cloud context, the working units are complete software solutions and hardware offerings, which increase the complexity faced in SOA environments [3]. These cannot be described by a specific service description language (SDL), but usually by SLA documents, written in natural language. Evidently, this increases the intricacy and entire thinking of resource discoverability. Lastly, since the scope of the project is to deliver a usable platform, Human-Computer Interaction (HCI) and usability aspects will also have to be considered when designing StakeCloud, to support user acceptance.

## IV. Proposed Solution

We envisage that the stakeholder requirements communication problem and matching the consumers' needs to providers' offerings can be solved by a platform which acts as a marketplace, bringing both sides together. Our concept for such a platform is depicted in Figure 1. The main stakeholders illustrated are the cloud service consumers, the enablers, and the cloud service providers. The enablers are optional stakeholders in this representation since cloud solutions can either be offered directly by providers to consumers, or using intermediary entities which act as service aggregators represented by enablers.

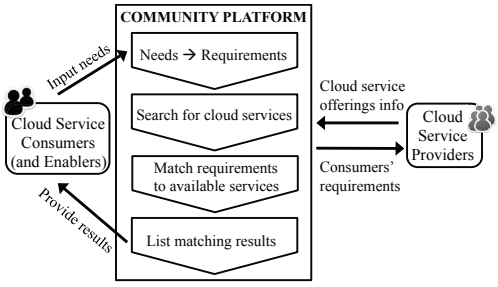


Figure 1. Our envisaged platform for supporting the communication of needs and the identification of cloud services.

A possible scenario which illustrates the workflow on the platform and provides a conceptual perspective is the following. A cloud service consumer needs a particular cloud solution, data storage for video files bigger than 3 GB for instance. Since he does not know what available offerings best match his needs, he chooses to use our solution and inputs the needs into the platform. There, in a dynamic interface, he is allowed and guided to elaborate his request and provide further details which are specific to data storage cloud resources; these needs are then interactively turned into well-defined, structured requirements. As shown in Figure 1, based on the elicited requirements, a search on the platform is performed, and the requirements are then matched to the best fitting data storage cloud services found. The list of results generated is shown to the consumer and then, based on the recommendation of the platform, he can choose one service. In the situation when his requirements are not matched to any available cloud service, they are stored in the platform database and made available as "unmet user requirements". These can be used by cloud service providers interested in extending their offering by meeting more unfulfilled end-user needs. The platform permanently maintains and updates a database containing cloud service offerings extracted from cloud providers.

To ensure consumers' privacy regarding their needs and searches, the community platform does not ask for the identity of the cloud service consumers. Therefore, the saved needs turned into requirements cannot be linked to their source, when made available to cloud providers. This way, if consumers consider that their search for cloud resources is confidential and, e.g., they do not want to disclose their choice of cloud providers to competitors, this is not an issue when using our proposed solution.

## V. Research Methodology and Validation

Firstly, we conducted a *systematic literature review* on the principal stakeholders of cloud systems, focusing on their needs and roles. Then, having built the stakeholders map, the literature review was extended to cover the communication issues which are raised by the particular features of cloud computing, such as distribution and diversity of resources. We looked into the methods currently used by cloud consumers to identify the needed services, and investigated the existing methods utilized by providers to find out about consumers' requirements. All these activities constituted the basis of our research project, addressing RQ 1. Then, a *domain analysis* enabled us to have a very early assessment of the usefulness of our idea. This consisted of discussions with RE experts, cloud services users and representatives of two cloud service providers. These further contributed to addressing RQ 1 and also represented a first step towards trying the research idea with potential future real users. Based on these investigations, we developed the *conceptual solution* of the envisaged platform, depicted in Figure 1.

Currently, we are performing a *literature review* on methods to elicit cloud consumers' requirements using the community platform. The conclusions based on the results collected so far are that the user interface will have to be thoroughly dynamic and able to self-adapt depending on user-input and choices made (e.g. if the consumer needs hardware resources or infrastructure or software, and what kinds of features he/she specifies). In addition, we will study natural language processing methods and have discussions with field experts, for potential use, if we find that the dynamic features of the platform do not suffice. These activities and methods address RQ 2.1, and similar approaches will be taken to address RQ 2.2 and RQ 2.3. The starting point for RQ 2.2 is represented by the WSLA framework [20,21], which could be used to retrieve requirements from SLAs.

Nevertheless, we will not limit ourselves to this and will also explore other alternatives which do not necessarily depend on the availability of SLA documents. Overall, to answer RQ 2.1-2.3, *action research* will be utilized, as described in [22].

As far as the *evaluation* is concerned, we will conduct iterative evaluation activities during our research project, which will assess the success of specific methods implemented, and also enable us to develop the solution incrementally, based on the results. For the final evaluation, we will conduct real world *case studies* to assess the degree to which the platform can be populated with the required data – from both consumers and providers, and to assess the satisfaction of the stakeholders with the solution delivered. For achieving the latter, we will study (a) whether they can actually find solutions to their problems, provided that the data exists on the platform, and (b) if nothing can be found, if the unmatched needs will be turned into requirements, so that providers can further utilize them. To mitigate the threat to external validity, we plan to involve in the case studies both individual consumers and organizations requiring cloud resources. In addition, we will use partner cloud service providers to evaluate the success of requirements elicitation with the StakeCloud platform.

## VI. State of Work

Having identified the requirements for the envisaged community platform, we defined the conceptual solution for StakeCloud, described in Section IV. At present, we are simultaneously conducting a literature review on methods which can answer RQ 2.1 and working on the user interface. We will then continue with RQ 2.2 and RQ 2.3 in an iterative fashion (implementation and evaluation), and plan to evaluate and complete the research project by early 2016.

## VII. Contributions and Conclusion

The research significance of this project lies in extending the state-of-the-art in stakeholder requirements communication in cloud systems and cloud resource identification. We will contribute to gaining a deeper understanding in solving the problem of mapping consumer needs to available cloud services from different providers. Therefore, we foresee that this project will enrich the knowledge in a key field: RE for Cloud Computing.

In this sense, our *main contributions* are the following. Our solution will support consumers to find the most appropriate cloud services, from various providers, which are mapped to their needs. As far as providers are concerned, they will have a dedicated place, the StakeCloud community platform, which collects new requirements from relevant consumers. Therefore, our approach has two-way benefits, for both providers and consumers (companies and individual end-users). We envision that, in the long-term, this work will contribute to the general trend of turning cloud computing into a utility, available anytime, anywhere.

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